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ABSTRACT

Peer oral protocols and group oral protocols were assessed for their use in improving certain analytic skills of undergraduate college students at a liberal arts college in Alabama. In association with the study, the theoretical and experimental literature on the use of peer and group educational interventions is outlined briefly. Subjects were divided into two classes according to their personal academic schedules. One class contained four students, and the other class contained nine students. Both groups were pretested using the Whimbey Analytic Skills Inventory (WASI). Both groups used text material, problems, and exercises selected from those developed by A. Whimbey and J. Lockhead (1984), and both groups were exposed to an open-ended problem. Demands on tacit knowledge and specific manipulative skills were held to a minimum. The nine-student class received the peer intervention, while the four-student class received the group intervention. Both classes were post-tested using a different form of the WASI. Results indicate that the class that received the group intervention showed no observable improvement, while the class that received the peer intervention showed significant improvement. A 27-item list of references and three data tables are included. (TJH)

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A COMPARISON OF THE EFFECTS OF TWO ORAL PROTOCOL INTERVENTIONS ON COLLEGE STUDENTS' ANALYTIC SKILLS: A PILOT STUDY

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Many researchers have observed that working together in small groups and that peer tutoring can greatly enhance the learning and mastery of concepts. Recently, studies concerning doing and learning mathematics cooperatively have begun to appear in the literature. This study attempted to show that Peer and Group Oral Protocols (POP and GOP respectively) could be used effectively to improve certain analytic skills of college students.

Volunteers from the student body of a small, private, co-educational liberal arts college in Alabama participated in this pilot study. They were divided into two classes according to their personal academic schedule. One class contained four students while the other contained nine students. Both groups were pre-tested using the Whimbey Analytic Skills Inventory (WASI). The class with nine students received the POP intervention and the class with four students received the GOP intervention. Both classes were subsequently post-tested using a different form of the WASI.

It was found that the class that received the GOP intervention showed no observable improvement (p-value=.125). The class that received the POP intervention showed significant improvement (p-value=9.76×10^{-4}).

The differences were compared (p-value=0.03), and at the α=5% level, there was a significant difference in the two interventions with the POP intervention giving the greater change.

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A Comparison of Two Oral Protocol Interventions
on College Students' Analytic Skills:
A Pilot Study

Introduction

Two factors from the past have greatly influenced the study of mathematics, and, while not bad in themselves, have frequently had detrimental effects. One of these factors is the mystique of doing mathematics in isolation. Working in isolation is undeniably an important part of problem solving though not the only way. The second factor is the perceived need for introducing competitiveness into the study of mathematics and the solving of mathematical problems. Often, competitiveness has become the goal rather than a means to an end and has totally obscured the real goal of solving problems and mastering mathematical concepts. This paper investigates the role of cooperation (cooperative learning) with structured conversation (oral protocol) in two groups of students of different size engaged in improving analytic and problem solving skills. One class engaged in Group Oral Protocol and the other in Peer Oral Protocol.

Some Theoretical Considerations

Because isolation and competitiveness have been such an integral part of the mathematics education folklore, the notions of cooperative learning and cooperative problem solving have only recently begun to appear in the literature (see Davidson, 1990 and Slavin, 1989). In the decade of the eighties many researchers had observed that working together in small groups (see Slavin, 1985, 1990; Johnson & Johnson, 1985; Johnson, Johnson, & Holubec 1990; Webb, N., 1985; Webb, C.,1985) facilitates learning. These same researchers have emphasized that cooperative learning groups and traditional small group teaching are very different. The

following chart adapted from Johnson, et al (1990) makes this distinction clear.

What is the Difference?

Cooperative Learning Groups	Traditional Learning Groups
Positive interdependence	No interdependence
Individual accountability	No individual accountability
Heterogeneous membership	Homogeneous membership
Shared leadership	One appointed leader
Responsibility for each other	Responsibility only for self
Emphasis on task & maintenance	Only task emphasis
Social skills directly taught	Social skills assumed & ignored
Group processing	No group processing
Teacher observation and intervention	No teacher observation or intervention

Other researchers (see Skinner, C., et al, 1990; Jenkins, J. R., et al, 1975; and Greenwood, et al, 1985) had demonstrated that peer tutoring, particularly that style which emphasizes immediate feedback, can greatly enhance the learning and mastery of concepts on the part of both tutor and tutee. In addition, numerous mathematicians have attempted to examine how they have learned and done mathematics (see Polya, 1945; Hadamard, 1945; Poincare, 1913; Halmos, 1985) and have pointed out that learning to ask the right questions greatly enhanced their work. In a related set of papers, Dubinsky, et al, (1986, 1989) have emphasized the need for the individual learner or problem solver to construct or to reconstruct those mental schema with which to deal with the situation, that is, either learning or problem solving.

Researchers, both constructivists and radical constructivists (Dubinsky, 1986), as well as constructivistic

behaviorists (Skinner, et al, 1989) point to expressing oneself as an important and necessary route to mastering a new concept. This idea of expressing oneself aloud leads to the notion of oral protocol. The concept of an oral protocol has appeared in several places in the literature and in diverse fields. In research on reading, Meyers (1989) and Davy (1983) refer to think-aloud processes to enhance cognition. Lochhead and Whimbey (1987) discuss thinking-aloud-pair-problem solving. In a similar vein, Hirabayashi & Shigematsu (1987) in a paper on metacognition refer to the inner teacher. DeGuire (1987), in addition, points to the importance of awareness of metacognition in problem solving. In an attempt to meld these ideas together and give them a heuristic structure, Wimbish (1989, 1990a, 1990b) gives the definition of an oral protocol for problem solving. The definition is given here for reference. An *oral protocol* for problem solving (and by extension, for mathematics learning) is a stylized and vocally expressed problem-solving (learning) conversation following a rigorously prescribed pattern. The pattern consists of a Polya-Cartesian series of questions. In the case of a problem solving protocol, the questions take the following form (the learning questions have a similar form, and will be considered in a separate discussion):

1. For what is the problem asking and how will a solution be recognized?
2. What approaches may be attempted?
3. What if ***this*** particular approach is tried?
4. What has been accomplished to this point?

The asking of each question and the stating of each attempted answer are accompanied by vocally expressed analysis, synthesis, and evaluation. An analysis is the breaking down of the problem

into smaller pieces for ease of understanding. Analytic skills are those which enable analysis. Synthesis, on the other hand, is the restructuring or reconstructing of the analyzed ideas into a proposed solution. Finally, evaluation in this context means to test the proposed solution for consistency: both logical consistency and consistency with the known facts. Most important, evaluation asks if the proposed solution answers the original question.

For the purpose of this paper there are three types of oral protocols (see Wimbish, ibid.):

1. Group Oral Protocol(GOP).
2. Peer Oral Protocol(POP).
3. Self Oral Protocol(SOP).

Group Oral Protocol is frequently described as group problem solving. It is based on methods used successfully in several industrial settings. The methods which most match the current investigation are those which have been adapted from those used by the Equipment Group of Texas Instruments in their Work Simplification Program. In a college classroom environment it can be implemented in either of two ways. The first method utilizes the instructor as the group problem-solving manager. The second version uses a member of the group appointed or elected to the position of manager. In either case, the manager's first responsibility is to introduce the problem; the second is to direct and encourage the solution of the problem. Third, it is the manager's job to insure that the rest of the group follows the oral protocol pattern and to enforce the vocalization of the analysis, synthesis, and evaluation at each step.

Peer oral protocol (POP) is a modification of peer tutoring or peer mentoring. The essential steps are as follows:

1. Students are randomly selected to form problem-solving pairs or dyads.
2. The class instructor then introduces the problem.
3. One of the students in the peer pair is designated as the solver and the other the manager.
4. The pairs then proceed in the manner outlined above for GOP.

Both methods are characterized by an emphasis on immediate feedback.

Self Oral Protocol means that the problem solver or learner engages, at least subvocally, in conversation with oneself. The idea is to emulate POP.

Several of the papers mentioned above point to the social effect of paired and larger group learning. However, the present study, rather than trying to account for this social effect, confined itself to comparing the effects of GOP and POP interventions on college students' analytic skills. SOP is not treated here even though the above mentioned mathematicians as well as some of the current researchers (Hirabayashi, I., & Shigematsu, K. 1987; DeGuire, 1987) indicate that SOP can be taken as an eventual goal of the other two types of interventions.

THE STUDENTS

Students from two separate classes designed to improve quantitative reasoning and reading served as subjects for this study. The class which employed a paired oral protocol procedure was divided into pairs and each student took turns serving as problem-solver and questioner. Those students designated as problem-solvers were instructed to verbalize their cognitive, sub-vocal, problem-solving behaviors while questioners asked questions

designed to help the solver through the problems and gave feedback to the answers given.

The second section used a group oral protocol. Leaders for the problem-solving sessions were selected by rotation. In this way each student was given the opportunity to serve in a leadership capacity. This person functioned as the questioner as described above, while the rest of the group functioned as the problem solvers in the analogous way.

Method

Subjects and Setting

Subjects for this study consisted of two classes of undergraduate college students who registered for a course designed to improve analytic reading and cognition. The course was offered at a private, co-educational, liberal arts institution in Alabama. One class contained four students while the other contained nine students.

The study was conducted in the same college classroom. The same instructor served as the experimenter for both classes.

Curricula Materials

Both classes used text material, problems, and exercises selected from Whimbey and Lochhead (1984). In addition, midway through the class an open-ended problem, which had been devised by the instructor, was posed and several possible solutions were developed and discussed by the students.

Insofar as possible, problems were selected which did not require specific manipulative skills. Thus, problems which demanded complex algebraic processes were avoided. Also, those problems which involved more than a rudimentary knowledge of geometric ideas were omitted. Consequently, demands on tacit knowledge were held to a minimum in order to focus on the

development of cognitive skills. In order, the specific items with which the students worked were:

1. General or word analogies.
2. Figural analogies.
3. Algebraic relationships.
4. Geometric relationships.
5. Approaches to open-ended questions.

Pre-tests

One dependent variable was used to measure increases in analytic skills: the Whimbey Analytic Skills Inventory test (WASI). Two other tests were administered to validate the WASI test: the analytic section of the GRE and a test, currently under development by the author, to indicate the level of the student's Piagetian development. The scores of the latter two tests are not reported in this paper.

Procedures

General.

Subjects for this study consisted of students who registered for a course in analytic skills development. During the first class meeting the instructor not only introduced the subject matter and the methods of instruction but also solicited informed consent to participate in this study from all the students who registered for the course. Any student not wishing to participate was given the option to take the course with another instructor at another time. The class with four students was assigned to the group oral protocol (GOP) intervention. The GOP class met every Monday from 2:30-3:30 PM for twelve consecutively scheduled weeks. The class with 9 students was assigned to the paired oral protocol (POP) intervention. The POP class met every Wednesday from 2:30-3:30 PM for twelve consecutively scheduled weeks.

During the second scheduled class meeting of both sections, the analytic skills of each student were assessed using the WASI pre-test. On the third class meeting the analytic section of the GRE was administered. On the fourth class session the instructor returned the graded WASI pre-test to each student and reviewed the correct results. No feedback on the interpretation of the individual scores was provided. During the fifth session, the subjects were given a test designed to assess Piagetian levels of cognitive development. In the sixth session, depending on their section, the subjects were instructed in group or paired oral protocols. In sessions seven through ten, students implemented either the GOP or POP intervention procedures. In the final sessions the students were given a post-test to determine their progress.

At the start of the sixth class students in the GOP section were taught how to perform both the problem solver and manager roles of this intervention. The instructor used modeling, demonstration, and immediate corrective feedback to train students in these procedures.

The role of the instructor was to maintain the integrity of the group function. When a group under a particular manager had successfully completed the solution of a problem, a new manager was appointed and the newly organized group proceeded to work on the next problem.

For those students in the POP section, at the start of the sixth class students were randomly paired and taught how to perform both the problem-solver and questioner roles. The instructor used modeling, demonstration, and immediate corrective feedback to train students in the POP procedures. The instructor's role was to maintain the integrity of the pair function. When a pair had successfully completed the solution to a problem, the students interchanged roles and proceeded to work on the next problem.

Statistical Considerations.

Because of the small size of the samples, non-parametric statistical procedures were applied to the data to minimize distortion.

To determine the non-parametric statistics for the pre-tests, the data were analyzed according to the Wilcoxon Rank Sum Test.

To analyze the information provided by the post-tests' scores, the following procedures were followed.

1. The differences between pre- and post-tests were calculated.
2. A Wilcoxon Signed Rank Test was performed on each set of differences.
3. A Wilcoxon Rank Sum Test was performed using the two sets of differences as the independent samples.

Statistical Conclusions

The pre-test data were analyzed using sample sizes of 4 and 9. The Wilcoxon Rank Sum statistic was 17.5 which has a p-value of 0.106. This says that before the oral protocol interventions there was no statistical difference in the two groups. When the differences between pre- and post-test were compared and the Wilcoxon Rank-Sum test was applied and a statistic of 14.5 was found which has a p-value of .03. Thus, the null hypotheses of no difference was rejected in favor of the alternative: that there was a difference and that the POP intervention gave the greater change. Using the Mann-Whitney test for two independent samples provided the following results. A test statistic of W = 14.5 was obtained giving a p-value of 0.0224. This says to reject the hypothesis of the medians being equal in favor of the alternate that the POP scores were greater than the GOP scores.

Discussion.

The above results indicate that students working together under the POP intervention appreciably improved their analytic skills. It has been suggested by Skinner, et al (1989) that the POP intervention provides more opportunities to respond and more immediate feedback. These factors in turn effect improvement in analytic skills. The disadvantage to the POP intervention is that, in a large class setting, the number of groups might prove unmanageable. On the positive side the students seem to be less intimidated. However, there is a tendency among students for the conversations to stray to topics other than the assigned problem. Even so, the students do get the chance to try to express themselves mathematically.

Care should be taken in the interpretation of the results of using the GOP intervention. It was frequently clear that the progress of the group was dependent on the leader. If the leader performed well in his/her role, then the problem solvers did also. The advocates of groups point to the fact that the more people in a group the more varied the ideas that will emerge. However, more people means fewer opportunities to respond.

If one attempts to use GOP in an actual classroom setting, there are some things to be aware of:

1. Everyone in the class needs to learn how to function both as a group leader and as a participant as an integral part of the education experience.
2. Students are frequently reluctant or are apparently unable to function in either of the defined roles.
3. The above difficulties usually can be overcome by using an appropriate mixture of positive encouragement and patience, and by reminding the students that many industrial

situations will require that they be able to function successfully in some sort of participatory or cooperative problem-solving group.

Currently under development and investigation (Wimbish, 1991) is the feasibility of using heterogeneous grouping of three students and trying to capture the best of both GOP and POP.

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APPENDIX

Table I describes some of the characteristics of the students in the GOP class. Table II describes the POP class.

Table II Student Characteristics(GOP)

St. No.	Age	Sex	Race	Major	H.S. Size	Col Gen	H.S. Math	Col Math	Class
1.	21	M	W	MATH/FIN	1600	1	2+	5	3
2.	21	F	W	PE	120	3	1	2	4
3.	20	F	B	CHEM	1400	2	2++	3	2
4.	20	F	B	MANAGE	1400	1	2	0	3

Table III Student Characteristics(POP)

St. No.	Age	Sex	Race	Major	H.S. Size	Col Gen	H.S. Math	Col Math	Class
1.	21	F	W	MATH/CS	1500	3	2+	6	3
2.	21	M	W	HIS/REL	425	3	2	0	4
3.	18	F	W	UND	1000	1	2+	1	1
4.	20	F	W	ENG	1400	2	2+	4	3
5.	20	M	W	MATH	900	2	2+	1	2
6.	21	F	W	MARKET	800	2	2+	1	4
7.	21	M	W	BIO	1500	2	2+	3	4
8.	20	M	W	MATH/CS	2000	2	2+	2	1
9.	19	M	W	ENG/HIS	700	2	2+	1	2

When the Wilcoxon Signed Rank test was applied to both sets of differences, the p-values of .125 and 9.76E(-4) were obtained.

Summary of GOP scores

St. No.	Pre-Test	Post-Test	Diff-erence
1.	26	28	2
2.	17	20	3
3.	32	30	-2
4.	23	26	3

Summary of POP scores

St. No.	Pre-Test	Post-Test	Diff-erence
1.	30	36	6

2.	24	29	5
3.	28	30	2
4.	31	37	6
5.	28	34	6
6.	26	31	5
7.	33	37	4
8.	33	37	3
9.	34	37	3